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Limit Orders, Trading Activity, and Transactions Costs in Equity Futures in an Electronic Trading Environment

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ABSTRACT

The behaviour of limit order quotes and trading activity are studied using a unique and rich database that includes the identity of market participants from a fully automated derivatives market. The analysis is performed using transactions records for three aggregated trader types and three trade identifiers, with trades stamped in milliseconds for the SXF, the equity futures contract of the Montreal Exchange. The identifiers distinguish trades between principals; agency based trades, as well as transactions that are conducted for risk management as opposed to speculative purposes. Agency related trades are shown to represent the largest amount of trading activity relative to other account types. Over 90% of trades in this electronic market are limit orders. The limit order book, especially the depth 1 order, has a dominant role in providing liquidity and in explaining market participants' trading behaviour. Participants in the SXF reference their trades to the best limit order depth. Hence, investors with large positions or investors who want to build a large position have to strategically split large orders to close/build their position, according to the depth of the best limit order, to ameliorate price impact and information leakage effects. In addition, the results show that traditionally measured spreads have no relationship with trading costs.

Key words: *Limit Orders, Trading Activity, Transactions Costs, Electronic Trading*
JEL Classifications: G13, G14, G18

1. INTRODUCTION

Many exchanges in the world have shifted to the computerized trading systems for equities or derivatives. This shift has in part been driven by the belief that the computerized trading offers lower transaction costs than traditional floor-based trading systems. One of the distinguishing features of a computerized trading market vs. a floor trading market is its transparent limit order book. Whether or not the increase in transparency of the computerized market comes at the expense of higher transactions costs and diminished liquidity has been a matter of considerable debate in the literature. The purpose of this study is to provide new evidence on this score using quotations and trades from an electronic market that operates via a limit order book. Our database is particularly rich in that it captures differences in transactions costs and trading activity between principals (vs. agents) as well as transactions that are conducted for risk management as opposed to speculative purposes.

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A number of theoretical models have been proposed on how the limit order book affects liquidity and conveys information about the market. Such information might be expected to affect the trading conduct of market participants (e.g. Glosten, 1994; Handa and Schwartz, 1996; Foucault, 1999; Handa et al., 2003 and Van Achter, 2009). Foucault et al. (2005) propose an equilibrium model for order placement and argue that the proportion of patient traders in the population and the order arrival rate are the key determinants of the limit order book dynamics. In addition, a number of empirical studies have examined the order submissions process as market conditions change (e.g. Biais et al., 1995; Griffiths et al., 2000; Ahn et al., 2001 and Hollifield et al., 2003). Chan (2005) find orders at the best quotes react more quickly and completely to the adjustment than orders that are far away from the best quotes using the limit-order book and previous price movements for active stocks traded on the Stock Exchange of Hong Kong. Moreover, several other studies have appeared that examine the role of the limit-order books in supplementing liquidity. For example, Degryse et al. (2005) analyze the resiliency of a pure limit order market and find that relative to the sample average, depths stay around their mean before and after aggressive orders, whereas spreads return to their mean after about twenty best limit updates. The initial price impact of the aggressive order is partly reversed in the subsequent transactions. Coppejans et al. (2003) study the resiliency of the Swedish stock index futures market (OMX) and find that shocks to depth are restored in less than 60 minutes.

On the whole, the role of information contained in the limit order book in influencing participants' trading behaviour remains an unsettled matter in the literature. Madhavan et al. (2005) document a ***reduction*** in liquidity on the TSE following the increase in order book disclosure. They report an increase in quoted and effective spreads, reduction in depth at the best quotes and an increase in volatility. Bortoli et al. (2006) show that after the increase in pre-trade transparency limit of its limit order book, the SFE experienced a ***reduction*** in depth (mean and median), and some widening of bid-ask spreads. These studies suggest that in a transparent market, limit order traders charge market order traders a higher premium for execution certainty by withdrawing depth from the best quotes, or by increasing bid-ask spreads. In sharp contrast, Boehmer et al. (2005) document a reduction in effective spreads on the NYSE following the introduction of the Open Book, consistent with an ***increase*** in market liquidity.

Our analysis is performed for one of the most important futures products on the Montreal Exchange, the S&P/TSX 60 index futures (SXF) contract. Since 2001, the Montreal Exchange has operated as a fully automated derivatives market and currently serves as the exclusive market for financial derivative products in Canada. The transaction records are timed by milliseconds and reflect actual trading activity that spans the period January 2005 to May 2006. To the best of our knowledge, our work is the first attempt to use actual trading records for a comprehensive set of trader categories to study the limit order book in financial futures products.

We find that that most transactions (well over 90%) in this electronic market are from limit orders. In addition, measures of trading activities and traditionally measured spreads have no relationship with trading costs. Limit orders in the electronic system of the Montreal Exchange serve to replace traditional market markers to provide market liquidity. The order information shown on the screen systematically influences the trading behaviour of participants in the markets. Participants in the markets respect the limit order book, especially the quotes of first priority order (best 1), to make their trading decisions. We find that SXF

market in consistent with a dynamic equilibrium process: and the size of best 1 quote is much more than the size of transaction per trade in. In particular, the liquidity/buffer provided the best 1 quote is responsible for that measure of trading activities that have no demonstrative relationship with trading costs.

The remainder of this paper is organized as follows: in the Section 2, we describe the data set used in this work. The empirical analyses follow in Section 3. The paper concludes in Section 4.

2. DATA

The Montreal Exchange is the exclusive exchange for trading financial derivative products in Canada. In 2001, the exchange became the first traditional exchange in North America to be fully automated. Clients' orders are filled on a "first in, first out" (FIFO) basis. Market orders to buy futures contracts are executed at the offer price (ask); market orders to sell are executed at the bid price (bid). However, an investor wishing to buy or sell at a specific price can provide a limit order. This order is registered in SAM's (Montréal Automated System) electronic order book and is executed when there is a counterparty interested in transacting at that price. Orders are matched and both orders are filled at the specified price for the smallest quantity posted. Since all of the trading of any specific futures contract is concentrated on one trading platform, SAM, participants are assured of buying at the lowest offer price or selling to the highest bid.

The Exchange also provides a system of specialists and market-makers. The specialist is responsible for the opening of each product, and is required to be at his or her post no less than 30 minutes before the opening signal of a trading session. Market-makers are obligated to maintain 50% of their quarterly activities in their assigned product. Transactions of specialists and market-makers in any security on which they have assumed responsibilities are required to be of a stabilizing nature. They are prohibited from making trades that may be disruptive of stability, such as purchases (sales) made at a price above (below) the last preceding different –priced trade while establishing or increasing a position.

The S&P/TSE 60 index futures (SXF) contract is one of the most important futures products in the Montreal Exchange. The underlying product of the SXF is the S&P/TSE 60 index, an equity portfolio composed of 60 highly liquid Canadian equities. Standard & Poor's Corporation calculates and disseminates index prices. The SXF contract is quoted in index points, expressed to two decimals and the nominal value of one contract is C$200 times the index. The minimum price fluctuation of SXF is 0.05 index points. The value of 0.10 index point change is C$20 per contract. SXF contract months are March, June, September and December; and it is cash settlement and trades between 9:30 a.m. to 4:15 p.m. (EST).

The data that we use in this study are considerably richer than those used in most previous studies that we are aware. The sample covers the 356 trading day period from January 2005 to May 2006. Our data allow us to identify trades as Limit, Market or Market on Opening transactions. Our data set provides real time quotes for bid and ask positions at various prices. The best bid price is defined as the highest price a prospective buyer is prepared to pay at a particular time for trading the futures contract. In the analyses, the variable **Best 1 Bid** is defined as the best bid depth, which corresponds to the sum of all bid sizes (number of contracts) that are submitted as limit orders for trading at the best bid price for market participant bid quotations that are equal to the best bid price. **Best 2 Bid** is the second best bid

depth, and so forth. The best ask (or offer) price is the lowest price at which someone who owns the contract offers to sell it. We define **Best 1 Ask** as the best ask depth, which is the sum of all ask sizes (number of contracts) that are submitted as limit orders to trade at the best ask price for market participant ask quotations that are equal to the best ask price. **Best 2 Ask** is the second best ask depth.

In addition we have two sets of identifiers for each transaction to distinguish between those that were buyer or seller initiated (buy or sell). First, each buy or sell is marked by four types of aggregated accounts: Client, Pro, Shareholder NonClient and Firm. **Client accounts** are defined as accounts established by an approved participant that is confined to Exchange transactions executed by and positions carried by the approved participant on behalf of his clients. **Firm accounts** are accounts established by an approved participant, that is confined to Exchange transactions executed by and positions carried by the approved participant on behalf of the approved participant. **Pro accounts** are accounts established by an approved participant, that is confined to Exchange transactions executed by and positions carried by the approved participant on behalf of a market maker. A Pro can be a market maker or a liquidity provider. In addition, the trading records also identify each buy or sell as representing transactions of Hedgers, or Speculators, or Market Makers. Since Shareholder NonClient only has very few transactions in the records, we use the trading records on the Client, Pro, Firm account categories and transactions by Hedger, Speculator and Market Maker groupings in our analysis.

Similar to Locke and Venkatesh (1997), the nearby SXF contract is selected each day, and it is rolled forward to the subsequent contract on the date when the maximum daily trading volume (Client account) switches from the nearby contract to the subsequent contract.

3. EMPIRICAL ANALYSES

3.1. Transaction Costs and Trading Activity

Several studies have appeared that explore the relationship between trading activity and transaction costs, and typically find that there are economies to scale in trading. Most of these studies use bid-ask spreads as measures of transactions costs. For example, Demsetz (1968) and Epps (1976) find that trading activity is inversely related to trading costs on NYSE stocks. Martell and Wolf (1987) conclude that trading volume is not only a function of volatility, but also of open interest, interest rates, exchange rates, and other variables. Haller and Stoll (1989) reported an inverse relationship between bid–ask spreads and trading volume in the German auction equity market. In addition, George and Longstaff (1993) document a negative relationship between transaction rates and bid–ask spreads for the S&P 100 index options market. Wang et al. (1994) state that the major factors affecting bid–ask spreads are price risk, trade volume, and market competition. Wang et al. (1997) report a positive relationship between trading volume and intraday price volatility, and an inverse relationship between trading volume and bid–ask spreads, after controlling for other factors.

Locke and Venkatesh (1997) show that bid-ask spreads are extremely problematic measures of transactions costs. For spreads to measure true transactions costs, it must be the case that customers trade exclusively with market makers. This assumption is clearly violated by many trading venues, particularly electronic platforms. In addition, as Stoll (1989) notes, even if all trades are mediated through market makers, the quoted bid-ask spread overstates actual transaction costs if some customers are better informed than the market makers or market

makers adjust the bid – ask spread prices to manage inventory levels. Real world factors also imply that bid-ask spreads are not the best measure of the costs of trading, since inter-customer trades do take place in most financial markets that may eliminate transaction costs in aggregate.

To improve upon spreads as measures of transactions costs, a number of studies have used Computerized Trade Reconstruction (CTR) audit trail data from the CME and employ accounting FIFO (First in, First out) trading profits to estimate the transaction costs (e.g. Chang et al., 1994; Fishman and Longstaff, 1992; Manaster and Mann, 1996; Chang and Locke, 1996; Locke and Venkatesh, 1997; Ferguson and Mann, 2001; Locke and Sarajoyi, 2004 and Kurov, 2005). Accounting FIFO trading profit estimates provide a direct measure of transactions costs when transactions can be classified by trader identity. Similar to Locke and Venkatesh (1997), Ferguson and Mann (2001), Locke and Sarajoyi (2004), and Kurov, (2005), we use accounting FIFO estimates to estimate trading costs, but with a much more refined data set[1].

In this study, we calculate three cost/profit estimates on each day. First, we use the accounting FIFO rule to determine trading profits per contract (PROFIT TRADE) and obtain the inventory positions for each of the six (trader) account types on the SXF. Second, the profit settled per contract (PROFIT SETTLED) for the inventory positions of each account type is determined by assuming that the inventories in each aggregated account are settled at the closing price of each contract. Finally, we estimate average profits per contract for each type of account as the weighted average FIFO profits and settled profits of inventories with weights given by the number of contracts traded or settled.

To illustrate the FIFO rule, suppose that there are only four transactions during a day from investors in a Client account. At time t1, investors in the Client account buy 50 contracts of SXFH with a price of 500.0; at time t2, investors in the Client account sell 20 contracts of SXFH with a price of 500.2; at time t3, investors in the Client account buy 30 contracts of SXFH with price equal to 500.3; at time t4, investors in the Client account sell 58 contracts of SXFH at the price of 500.5. Suppose also that the average last bid and ask for SXFH at the end of the day is 500.8.

First, we use the accounting rule of FIFO to get profit trade per contract (the value of 0.10 index point change is C$20 per contract):
C$20 *(20*(500.2-500.0) +30*(500.5-500.0) +28*(500.5-500.3))/78= C$6.3077 per contract; the inventory position in the Client account on SXFH is long 2 contracts at the end of that day.

Second, the profit settled per contract for the inventory position is:
C$20 *2*(500.8-500.3)/2 =C$10.0000 per contract.

Finally, average profits per contract for the Client account on that day are:
(C$6.3077*78+ C$10.000*2)/80=C$6.4000 per contract.

[1] This procedure is alluded to in Stoll (1989), and also implemented by Beebower and Priest (1980) and Baesel et al. (1983), among the other studies references.

Account	Dependent (C$)		Independent Variable								
Panel A: Ask			*C*	*Q*	*TV*	*Std Q*	*Std TV*	*Std P*	*D*	*P*Value	*DW*
	Average	Coef.	-108.36	-6.5817	34.446	1.0964	-1.7344	22.501	44.448	0.1544	2.0290
Client	profit	Prob.	0.0147	0.1661	0.0739	0.2522	0.2127	**0.0492**	0.3661		
	Profit	Coef.	-180.09	-1.7260	54.328	-0.1812	-2.1517	28.877	-12.279	**0.0182**	2.1070
	trade	Prob.	0.0000	0.7103	**0.0041**	0.8466	0.1145	**0.0101**	0.7986		
	Average	Coef.	118.46	10.430	-43.779	-1.6332	8.0110	-41.331	-229.30	0.2223	1.9660
Firm	profit	Prob.	0.1439	0.2289	0.1292	0.3632	0.2295	0.0539	0.5167		
	Profit	Coef.	262.79	2.6967	-70.060	-0.5724	9.8841	-53.598	-189.73	0.0112	2.0240
	trade	Prob.	0.0005	0.7376	**0.0092**	0.7316	0.1110	**0.0073**	0.5637		
	Average	Coef.	-8.8075	0.8319	12.349	-0.3283	0.7803	0.0900		0.7531	1.9390
Pro	profit	Prob.	0.7873	0.6309	0.6275	0.3297	0.9419	0.9811			
	Profit	Coef.	28.610	0.5111	-11.752	-0.2506	6.1457	-0.7388		0.9035	2.0190
	trade	Prob.	0.3775	0.7662	0.6418	0.4535	0.5632	0.8447			
	Average	Coef.	25.380	2.5216	-4.5622	-0.0812	0.2887	-28.589	-13.314	0.3408	1.8370
Hedger	profit	Prob.	0.5932	0.6246	0.7904	0.9385	0.8548	**0.0258**	0.8061		
	Profit	Coef.	66.193	0.5115	-14.229	0.4727	0.8518	-30.773	-17.569	0.1347	2.0680
	trade	Prob.	0.1045	0.9078	0.3335	0.6002	0.5288	**0.0052**	0.7055		
	Average	Coef.	-8.1343	-0.8392	5.1157	-0.5426	-1.5313	12.491	62.172	0.6682	1.5440
Speculator	profit	Prob.	0.8905	0.8797	0.8694	0.6118	0.5125	0.3180	0.6018		
	Profit	Coef.	-52.582	-0.3300	12.938	-0.5783	-1.1283	17.443	28.987	0.3227	2.0570
	trade	Prob.	0.2249	0.9353	0.5703	0.4604	0.5101	0.0574	0.7398		
	Average	Coef.	0.5252	-1.1821	3.7974	0.1573	-0.4434	-0.1180	-161.44	0.1205	1.9160
Market	profit	Prob.	0.9834	0.4616	0.8321	0.6278	0.9326	0.9759	**0.0159**		
Maker	Profit	Coef.	37.822	1.8713	-25.596	-0.2179	-6.2998	-2.1435	-59.439	**0.0264**	1.9650
	trade	Prob.	0.1896	0.3057	0.2095	0.5549	0.2910	0.6297	0.4334		
Panel A: Bid			*C*	*Q*	*TV*	*Std Q*	*Std TV*	*Std P*	*D*	*P*Value	*DW*
	Average	Coef.	-124.68	0.9521	18.196	-0.0707	-0.9462	26.655	41.680	0.2766	2.0190
Client	profit	Prob.	0.0045	0.8290	0.3745	0.9401	0.5117	**0.0222**	0.4047		
	Profit	Coef.	-184.24	-0.3715	52.341	-0.4130	-2.0493	29.682	-12.183	**0.0196**	2.1100
	trade	Prob.	0.0000	0.9313	**0.0092**	0.6530	0.1461	**0.0092**	0.8030		
Firm	Average	Coef.	160.52	-7.9732	-10.588	1.3676	5.0756	-53.334	-136.08	0.2616	1.9620
	profit	Prob.	0.0463	0.3133	0.7241	0.4207	0.3660	**0.0149**	0.6195		
	Profit	Coef.	280.48	-4.4444	-55.807	0.4748	8.5710	-58.661	-140.28	0.0098	2.0220
	trade	Prob.	0.0002	0.5447	**0.0456**	0.7632	0.1006	**0.0040**	0.5813		
Pro	Average	Coef.	-12.538	0.4137	16.378	-0.2812	0.3575	0.1072		0.7412	1.9320
	profit	Prob.	0.6961	0.7724	0.5022	0.3576	0.9734	0.9779			
	Profit	Coef.	27.013	0.8279	-11.465	-0.3438	5.5310	-0.2964		0.8207	2.0220
	trade	Prob.	0.3965	0.5597	0.6358	0.2571	0.6034	0.9383			
Hedger	Average	Coef.	36.850	-0.9715	-0.3479	0.5765	0.0779	-30.775	-17.191	0.3390	1.8420
	profit	Prob.	0.4237	0.8384	0.9845	0.5784	0.9621	**0.0178**	0.7678		
	Profit	Coef.	69.355	-1.8266	-9.7559	0.9734	0.4283	-32.241	-5.0532	0.1182	2.0540
	trade	Prob.	0.0792	0.6543	0.5254	0.2735	0.7605	**0.0038**	0.9193		
Speculator	Average	Coef.	-10.911	1.2439	0.6629	-1.0037	-1.2623	14.237	54.240	0.6090	1.5390
	profit	Prob.	0.8539	0.8016	0.9835	0.3244	0.5940	0.2638	0.6501		
	Profit	Coef.	-55.256	0.1011	13.772	-0.7498	-1.0708	17.959	23.062	0.2732	2.0460
	trade	Prob.	0.2035	0.9778	0.5568	0.3148	0.5370	0.0547	0.7923		
	Average	Coef.	-0.1091	1.1906	-5.2203	-0.2607	-0.4202	1.0497	-151.65	0.1121	1.9310
Market	profit	Prob.	0.9966	0.3721	0.7583	0.3817	0.9360	0.7918	**0.0246**		
Maker	Profit	Coef.	30.657	3.8476	-30.007	-0.5564	-7.8699	-0.3455	-35.035	**0.0026**	1.9910
	trade	Prob.	0.2851	**0.0109**	0.1176	0.0985	0.1831	0.9386	0.6443		

Table 3.1 OLS Estimates of the Regression of SXF Transaction Costs with Measures of Trading Activity and Limit Orders.

Notes: OLS estimates of the regression of SXF daily transaction profit/Cost in C$ per contract and measures of trading activity and limit order are presented. In the table, *TV* is Mean Trade Volume. *Q* is the daily mean quantity of Best 1 Ask for Panel A and Best 1 Bid for Panel B. *D* is a dummy variable, which equals 1 when *TV* +3 * *Std TV* > *Q* + 3 **Std Q*. Std stands for standard deviation. *DW* is Durbin-Watson stat. *P*Value is the *p* value of the regression. *P* is transaction price. Profit trade is daily FIFO profit for each account type of Firm, Client, Pro, Hedger, Speculator and Market Maker. Average profit is the weight average profits of the FIFO profit and the profits of daily inventory imbalance settled at the closing price. The number of contracts traded or settled is used as the weight. *C* is constant term in the OLS model. The best bid price is defined as the highest price a prospective buyer is prepared to pay at a particular time for trading the futures contract. In the analyses, Best 1 Bid is defined as the best bid depth, which corresponds to the sum of all bid sizes (number of contracts) that are submitted as limit orders for trading at the best bid price for market participant bid quotations that are equal to the best bid price. The best ask (or offer) price is the lowest price at which someone who owns the contract offers to sell it. Best 1 Ask is the best ask depth, which is the sum of all ask sizes (number of contracts) that are submitted as limit orders to trade at the best ask price for market participant ask quotations that are equal to the best ask price. Value in Bold indicates significant at 5 percent level. Data for 356 trading days are used in the regression.

Since a buy /sell in an aggregated account could be closed but then immediately followed a sell/buy, our FIFO cost estimate is largely immune to any informational effects. As an extreme example, suppose an investor in the Client account buys 30 contracts of SXFH; then suppose that immediately after a millisecond, another investor in Client account sells 30 contracts of SXFH. The position in the Client account is closed in a millisecond. The calculated FIFO costs in this case will reflect only liquidity costs.

In this work, we first sort the records by the date and hour, and then by milliseconds to get the FIFO transaction series for a daily session. The last average of bid and ask price is used as the closing price on the trading day[2].

Many previous studies suggest that trading activity increases market liquidity. However, accurate measures of trading activity, such as trading volume per transaction are not available, and as a result, activity levels are usually measured by the number of transactions (McInish and Wood, 1992). In contrast, our data include the trading volume per transaction for each account type and the actual price executed, which we can use as the independent variables as specified in our model of the determinants of trading costs.

In particular, to further investigate the relationship between the transaction costs and trading activity, we estimate the following regression model:

$$Costs = C + \beta_1 Q + \beta_2 TV + \beta_3 Std\ Q + \beta_4 Std\ TV + \beta_5 Std\ P + D + \varepsilon \qquad (3.1)$$

where *Costs* is our measures of transaction costs; *C* is constant term; *Q* is the daily mean quantity of Best 1 Ask or Bid; *TV* is mean trade volume per transaction on each day; *P* is transaction price; and *D* is a dummy variable, which equals 1 when *TV* +3 * *StdTV* > *Q* + 3 **StdQ*. *Std* stands for standard deviation for the above measures.

OLS estimation results on both the Bid and Ask sides for three aggregated account types of Client, Pro, Firm and transaction by Hedger, Speculator and Market Maker are presented in Table 3.1. The results are similar whether we use the measures of Bid side or the measures of Ask side. Overall, the regression results show virtually no relationship between transaction costs and measures of market activity for the SXF. Most coefficients of market activity measures are insignificant at 5 percent level.

3.2. Limit Order Quotes and Trading of the SXF

Why are transactions costs unrelated to measures of trading activity? In this section, we explore the role of limit orders. In Table 3.2 we provide summary statistics on limit order quotes and limit order size. For each trading day, we cumulate the records of each limit order quote and limit order quantity that is submitted over the day. Table 3.2 reports the cumulative averages across all trading days in the sample. As is shown in the table, the Best 1 and 2 variables, which capture the number of contracts submitted as limited orders at best and second best prices for market participants are similar on the bid and ask sides (Panel A vs. Panel B).

In addition, the average of daily standard deviation of limit order quantity (Average *Std Q*), the average of maximum quantity of limit order in each trading day (Average *max Q*) or the mean of daily standard deviation of the average size of limit order per order (Std Average Size) are similar on the bid and the ask side.

[2] See also Switzer and Fan (2007).

	Average Mean *Q*	Mean Average Size	Average *Std Q*	Std Average Size	Average *Max Q*	Sample Days
Panel A: Bid Jan 05 - May 06						
Best 1	10.95	4.06	27.00	5.41	294.18	356
Best 2	11.47	4.49	11.02	4.58	134.40	356
Best 1 and 2	11.23	4.28	21.01	5.10	300.01	356
Panel B: Ask Jan 05 - May 06						
Best 1	10.24	4.00	26.76	5.60	287.63	356
Best 2	9.65	4.14	10.10	4.52	121.62	356
Best 1 and 2	9.95	4.07	20.50	5.17	288.51	356
Panel C: Bid Jan 05 - May 05						
Best 1	13.86	4.72	34.99	6.23	326.31	104
Best 2	14.02	5.19	13.29	5.27	127.52	104
Best 1 and 2	13.93	4.95	27.16	5.85	326.61	104
Panel D: Ask Jan 05 - May 05						
Best 1	13.20	4.67	34.93	6.51	336.88	104
Best 2	12.07	4.72	12.64	5.27	132.79	104
Best 1 and 2	12.66	4.70	26.86	6.09	337.27	104
Panel E: Bid Jan 06 - May 06						
Best 1	9.34	3.61	23.77	4.79	291.52	105
Best 2	9.58	4.09	10.19	4.64	162.99	105
Best 1 and 2	9.48	3.86	18.40	4.77	309.95	105
Panel F: Ask Jan 06 - May 06						
Best 1	8.48	3.54	23.18	5.21	267.90	105
Best 2	7.72	3.79	8.70	4.49	117.29	105
Best 1 and 2	8.09	3.67	17.53	4.92	268.07	105

Table 3.2 Summary statistics for SXF limit orders.
Notes: Summary statistics for limit order quotes for the SXF are shown. Daily statistics are used to calculate the averages. Average mean *Q* is the average of daily mean quantity of limit orders. Average *Std Q* is the average daily standard deviation of limit order quantities. Average *max Q* is the average of the maximum quantity of limit orders in each trading day. Mean Average Size is the mean of the daily average size of limit order per order. Std Average Size is the mean of daily standard deviation of the average size of limit order per order. The best bid price is defined as the highest price a prospective buyer is prepared to pay at a particular time for trading the futures contract. In the analyses, the variable Best 1 Bid is defined as the best bid depth, which corresponds to the sum of all bid sizes (number of contracts) that are submitted as limit orders for trading at the best bid price for market participant bid quotations that are equal to the best bid price. Best 2 Bid is the second best bid depth, and so forth. The best ask (or offer) price is the lowest price at which someone who owns the contract offers to sell it. We define Best 1 Ask as the best ask depth, which is the sum of all ask sizes (number of contracts) that are submitted as limit orders to trade at the best ask price for market participant ask quotations that are equal to the best ask price. Best2 ask is the second best ask depth. Best 1and 2 combine the records of the Best 1 limit order and the Best 2 limit order. The sample consists of 356 days from January 04, 2005 to May 30, 2006. Statistics of two sub-periods from Jan. 05 to May 05 and from Jan. 06 to May 06 are also presented.

Summary statistics for transactions cumulated on a daily basis are provided in Table 3.3. As shown in the panel A of the table, for the entire market (All account), the average of daily mean of the number of the nearby SXF contract traded per transaction (Mean Trade Volume) is 2.49 contracts and the average maximum number of the nearby SXF contract traded per transaction on each trading day (Max Trade Volume) is 262.92 contracts.

The Client category has a higher value in the average of the daily number of the nearby SXF contract traded (Number Trading) than the Firm, Pro, Hedger, Speculator or Market Maker categories. It is therefore quite obvious that Market Makers/Pros do not precipitate all Client transactions. Moreover, the Pro/Market Maker category exhibits the lowest values in Mean Trade Volume, Max Trade Volume and Std Trade Volume (the average of the standard deviation of the number of nearby SXF contract traded per transaction on each day) across the

six account types. These results suggest that Pros/Market Makers do not adjust their inventory level by incurring additional costs with a few large orders.

We also present the average of weighted price of the SXF transaction in our sample period with the weights determined by the number of contracts traded (Ave Weight Price), the average of daily mean transaction price (Mean Price), the average of the daily standard deviation of transaction price (Std Price), the average of the minimum transaction price on each day (Min Price) and the average of the maximum transaction price on each day (Max Price), respectively, in Table 3.3. Overall, the market of the SXF is not particularly volatile in our sample period: The average standard deviation of transaction price (Std Price) is only about 1.5; and the differences between Min Price and Mean Price or the differences between Max Price and Mean Price are small.

	Number Trading	Mean Trade Volume	Max Trade Volume	Std Trade Volume	Ave Weight Price	Mean Price	Min Price	Max Price	Std Price	Obs
Panel A: Jan. 05 - May 06										
All account	2236.79	2.49	262.92	7.98	597.14	597.13	593.97	600.38	1.52	356
Client	1664.43	2.67	253.67	9.05	597.14	597.14	593.99	600.36	1.52	356
Pro	1358.41	1.76	14.58	1.35	597.11	597.11	594.00	600.29	1.51	356
Firm	716.28	3.20	114.45	6.36	597.15	597.13	594.06	600.24	1.49	356
Hedger	1216.49	3.03	229.31	9.56	597.14	597.13	594.01	600.34	1.50	356
Speculator	1485.96	2.40	112.43	4.73	597.14	597.13	593.99	600.31	1.53	356
Market Maker	1065.37	1.67	16.71	1.27	597.13	597.12	594.02	600.26	1.50	356
Panel B: Jan. 05 - May 05										
All account	1749.63	2.76	235.84	8.19	524.22	524.23	521.92	526.59	1.14	104
Client	1174.05	3.06	233.16	9.76	524.23	524.25	521.94	526.58	1.14	104
Pro	1176.63	1.94	21.68	1.72	524.23	524.23	521.94	526.57	1.13	104
Firm	540.65	3.67	121.99	7.58	524.21	524.20	521.98	526.54	1.13	104
Hedger	781.13	3.59	181.03	9.98	524.22	524.23	521.97	526.55	1.13	104
Speculator	1167.19	2.72	152.11	6.36	524.23	524.23	521.94	526.58	1.15	104
Market Maker	995.32	1.87	22.99	1.57	524.24	524.24	521.95	526.57	1.12	104
Panel C: Jan. 06 - May 06										
All account	2873.98	2.19	323.30	7.97	672.55	672.53	668.54	676.68	1.89	105
Client	2227.10	2.30	**318.89**	9.00	672.55	672.53	668.56	676.66	1.89	105
Pro	1644.37	1.61	11.46	1.22	672.50	672.51	668.56	676.42	1.89	105
Firm	938.72	2.72	104.17	5.09	672.54	672.54	668.65	676.35	1.84	105
Hedger	1675.73	2.52	**310.85**	10.00	672.56	672.53	668.57	676.62	1.85	105
Speculator	1970.10	2.13	80.67	3.28	672.53	672.54	668.56	676.44	1.91	105
Market Maker	1180.10	1.44	13.20	0.97	672.51	672.52	668.62	676.39	1.87	105

Table 3.3 Summary Statistics for SXF Trading.

Notes: Summary statistics for daily transactions for SXF are presented. Number Trading is the average of the daily number of nearby SXF contracts traded. Mean Trade Volume is the average of daily mean of the number of nearby SXF contract traded per transaction. Max Trade Volume is the average maximum number of nearby SXF contract traded per transaction on each trading day. Std Trade Volume is the average of the standard deviation of the number of nearby SXF contracts traded per transaction on each day. Ave Weight Price is the average of weighted price of SXF transactions in our sample period with the weight determined by the number of contracts traded. Mean Price, Std Price, Min Price and Max Price are the average of daily mean transaction price, the average of daily standard deviation of transaction price, the average of the minimum transaction price on each day and the average of the maximum transaction price on each day, respectively. Client, Firm, Pro, Hedger, Speculator and Market Maker are the aggregated account indicators that either buy or sell are the transactions by Client, Firm Pro, Hedger, Speculator or Market Maker respectively. All account is for the transactions in overall market participants. The sample consists of 356 days from January 04, 2005 to May 30, 2006. Statistics of two sub-periods from Jan. 05 to May 05 and from Jan. 06 to May 06 are also presented.

Goettler et al. (2005) assert that the midpoint of the bid–ask spread is not a good proxy for the asset's true value. Instead, the transaction price is closer to the true value of the asset. Table 3.3 shows that Ave Weight Price is close to Mean Price; therefore, there is no evidence that the aggregated participants in any account category has persistent informational advantage over others. This result is consistent with Gilbert and Rijken (2006), who show that asymmetric information is less important in index futures markets.

Most important is that the Mean Trade Volume in Table 3.3 is much less than the Average mean *Q* in Table 3.2; furthermore, the Mean Trade Volume is markedly smaller than the Mean Average Size of the Best 1 quote. Hence, the Best 1 quote seems to play a key role in the SXF's market liquidity.

		Trading volume Less than the Best 1 limit order in trading days					
		Mean quote		Mean plus 1 sd of quote		Mean plus 3 sd of quote	
	Account	Number days	Percent of sample day	Number days	Percent of sample day	Number days	Percent of sample day
Panel A: Ask Jan. 05 -May 06							
	All	41	11.52%	306	85.96%	324	91.01%
	Client	24	6.74%	300	84.27%	323	90.73%
	Firm	16	4.49%	321	90.17%	348	97.75%
	Pro	347	97.47%	356	100.00%	356	100.00%
	Hedger	21	5.90%	293	82.30%	325	91.29%
	Speculator	55	15.45%	345	96.91%	350	98.31%
Mean plus 3 sd of Trading volume	Market Maker	343	96.35%	354	99.44%	355	99.72%
Panel B: Bid Jan. 05 -May 06							
	All	54	15.17%	308	86.52%	324	91.01%
	Client	41	11.52%	301	84.55%	323	90.73%
	Firm	15	4.21%	329	92.42%	347	97.47%
	Pro	354	99.44%	356	100.00%	356	100.00%
	Hedger	23	6.46%	299	83.99%	327	91.85%
	Speculator	74	20.79%	344	96.63%	350	98.31%
Mean plus 3 sd of Trading volume	Market Maker	346	97.19%	355	99.72%	355	99.72%

Table 3.4 Daily Trading Volume vs. the Best 1 Limit Order.

Notes: This table compares the daily mean plus 3 standard derivation of trading volume per transaction with daily Mean, daily Mean plus 1 standard derivation and daily Mean plus 3 standard derivation of limit order per record on both the Bid and Ask sides. The Best 1 limit order combines the Best 1 Bid and Best Ask 1 variables. The best bid price is defined as the highest price a prospective buyer is prepared to pay at a particular time for trading the futures contract. In the analyses, the variable Best 1 Bid is defined as the best bid depth, which corresponds to the sum of all bid sizes (number of contracts) that are submitted as limit orders for trading at the best bid price for market participant bid quotations that are equal to the best bid price. The best ask (or offer) price is the lowest price at which someone who owns the contract offers to sell it. We define Best1 Ask as the best ask depth, which is the sum of all ask sizes (number of contracts) that are submitted as limit orders to trade at the best ask price for market participant ask quotations that are equal to the best ask price. Column Number days are the number of days that Mean plus 3 sd of Trading volume is less than or equal to the Mean quote, Mean plus 1 sd of quote or Mean plus 3 sd of quote of limit order. Percent of sample day is based on actual trading day. The sample consists of 356 days from January 04, 2005 to May 30, 2006. Statistics of two sub-periods from Jan. 05 to May 05 and from Jan. 06 to May 06 are also presented.

		Trading volume Less than the best 1 limit order in trading days					
		Mean quote		Mean plus 1 sd of quote		Mean plus 3 sd of quote	
	Account	Number days	Percent of sample day	Number days	Percent of sample day	Number days	Percent of sample day
Panel C: Ask Jan. 05 -May 05							
	All	18	17.31%	97	93.27%	100	96.15%
	Client	11	10.58%	95	91.35%	99	95.19%
	Firm	11	10.58%	98	94.23%	101	97.12%
	Pro	103	99.04%	104	100.00%	104	100.00%
	Hedger	8	7.69%	94	90.38%	101	97.12%
	Speculator	20	19.23%	100	96.15%	101	97.12%
Mean plus 3 sd of Trading volume	Market Maker	101	97.12%	104	100.00%	104	100.00%
Panel D: Bid Jan. 05 -May 05							
	All	23	22.12%	97	93.27%	99	95.19%
	Client	20	19.23%	95	91.35%	99	95.19%
	Firm	9	8.65%	98	94.23%	101	97.12%
	Pro	104	100.00%	104	100.00%	104	100.00%
	Hedger	9	8.65%	95	91.35%	101	97.12%
	Speculator	29	27.88%	100	96.15%	101	97.12%
Mean plus 3 sd of Trading volume	Market Maker	103	99.04%	104	100.00%	104	100.00%

Table 3.4 (Cont.) Daily Trading Volume vs. the Best 1 Limit Order.

Notes: This table compares the daily mean plus 3 standard derivation of trading volume per transaction with daily Mean, daily Mean plus 1 standard derivation and daily Mean plus 3 standard derivation of bid and ask limit orders per record. The Best 1 limit order combines the Best 1 Bid and Best Ask 1 variables. The best bid price is defined as the highest price a prospective buyer is prepared to pay at a particular time for trading the futures contract. In the analyses, the variable Best 1 Bid is defined as the best bid depth, which corresponds to the sum of all bid sizes (number of contracts) that are submitted as limit orders for trading at the best bid price for market participant bid quotations that are equal to the best bid price. The best ask (or offer) price is the lowest price at which someone who owns the contract offers to sell it. We define Best 1 Ask as the best ask depth, which is the sum of all ask sizes (number of contracts) that are submitted as limit orders to trade at the best ask price for market participant ask quotations that are equal to the best ask price. Column Number days are the number of days that Mean plus 3 sd of Trading volume is less than or equal to Mean quote, Mean plus 1 sd of quote or Mean plus 3 sd of quote of limit order. Percent of sample day is based on actual trading days. The sample consists of 356 days from January 04, 2005 to May 30, 2006. Statistics of two sub-periods from Jan. 05 to May 05 and from Jan. 06 to May 06 are also presented.

The liquidity providing role of the Best 1 limit order is more obvious for Pros and Market Makers. The Mean Trade Volume plus three times the Std Trade Volume for the Pro category is 5.81 (1.76+3*1.35) contracts per transaction, which about half of the 10.95 contracts of the Average mean *Q* on the Best 1 quote. The Best 1 quote provides enough liquidity for market makers.

In addition, the values of Max Trade Volume for the whole sample period (Panel A of Table 3.3) are all less than 294.18 of the Average max *Q* for Best 1.This fact also implies that participants in the SXF ***must reference their trades to*** the best 1 limit order. In other words, investors with large positions or investors who want to build a large position have to strategically split large orders to close/build their position, according to the depth of the best 1 limit order, to ameliorate price impact and information leakage effects.

		Trading volume Less than the best 1 limit order in trading days					
		Mean quote		Mean plus 1 sd of quote		Mean plus 3 sd of quote	
	Account	Number days	Percent of sample day	Number days	Percent of sample day	Number days	Percent of sample day
Panel E: Ask Jan. 06 -May 06							
	All	11	10.48%	85	80.95%	94	89.52%
	Client	8	7.62%	81	**77.14%**	94	**89.52%**
	Firm	2	1.90%	96	91.43%	104	99.05%
	Pro	100	95.24%	105	100.00%	105	100.00%
	Hedger	10	9.52%	79	**75.24%**	91	**86.67%**
	Speculator	13	12.38%	104	99.05%	105	100.00%
Mean plus 3 sd of Trading volume	Market Maker	101	96.19%	105	100.00%	105	100.00%
Panel F: Bid Jan. 06 -May 06							
	All	18	17.14%	87	82.86%	94	89.52%
	Client	12	11.43%	84	**80.00%**	94	**89.52%**
	Firm	2	1.90%	97	92.38%	103	98.10%
	Pro	105	100.00%	105	100.00%	105	100.00%
	Hedger	11	10.48%	82	**78.10%**	93	**88.57%**
	Speculator	16	15.24%	104	99.05%	105	100.00%
Mean plus 3 sd of Trading volume	Market Maker	103	98.10%	105	100.00%	105	100.00%

Table 4 (Cont.): Daily Trading Volume vs. the Best 1 Limit Order.

Notes: Comparisons of daily mean plus 3 standard derivation of trading volume per transaction with daily Mean, daily Mean plus 1 standard derivation and daily Mean plus 3 standard derivation of limit order per record on both Bid and Ask side are shown. The Best 1 limit order combines the Best 1 Bid and Best Ask 1 variables. The best bid price is defined as the highest price a prospective buyer is prepared to pay at a particular time for trading the futures contract. In the analyses, the variable Best 1 Bid is defined as the best bid depth, which corresponds to the sum of all bid sizes (number of contracts) that are submitted as limit orders for trading at the best bid price for market participant bid quotations that are equal to the best bid price. The best ask (or offer) price is the lowest price at which someone who owns the contract offers to sell it. Best 1 Ask is the best ask depth, which is the sum of all ask sizes (number of contracts) that are submitted as limit orders to trade at the best ask price for market participant ask quotations that are equal to the best ask price. Column Number days are the number of days that Mean plus 3 sd of Trading volume is less than or equal to Mean quote, Mean plus 1 sd of quote or Mean plus 3 sd of quote of limit order. Percent of sample day is based on actual trading days. The sample consists of 356 days from January 04, 2005 to May 30, 2006. Statistics of two sub-periods from Jan. 05 to May 05 and from Jan. 06 to May 06 are also presented.

The role of limit orders, especially the best 1 limit order, in providing enough liquidity and determining participants' trading behaviour is also illustrated in Table 3.4, which examines the relationship between trading volume and the best 1 limit order on each trading day of our 356 sample days. We find that, in more than 80 percent of the 356 trading days in the sample, the daily mean plus 3 standard deviation of trading volume per transaction (Mean plus 3 sd of Trading volume) is less than the daily mean plus one standard deviation of best1 limit order (Mean plus 1 sd of quote) per record; and, in more than 90 percent of trading days, the daily mean plus 3 standard deviation of trading volume are less than the daily mean plus 3 standard deviation of best1 limit order (Mean plus 3 sd of quote). Sophisticated investors in this market (Pro and Market Maker) seem more likely to conduct their transactions at the best 1 limit order quote.

Table 3.5 presents additional evidence that the best 1 limit order for the SXF is a key determinant of the market liquidity. In 356 trading days, almost every day shows mean trading volume per transaction (Mean Trade Volume) less than the daily mean of the best 1

limit order per record on both Bid and Ask side for every aggregated accounts or the market as a whole (All).

Account	All	Client	Firm	Pro	Hedger	Speculator	Market Maker
Panel A: Ask Jan. 05 - May 06							
Number days	356	354	355	356	353	356	356
Percent of sample day	100.0%	99.4%	99.7%	100.0%	99.2%	100.0%	100.0%
Panel B: Bid Jan. 05 - May 06							
Number days	356	356	356	356	354	356	356
Percent of sample day	100.0%	100.0%	100.0%	100.0%	99.4%	100.0%	100.0%
Panel C: Ask Jan. 05 - May 05							
Number days	104	103	104	104	102	104	104
Percent of sample day	100.0%	99.0%	100.0%	100.0%	98.1%	100.0%	100.0%
Panel D: Bid Jan. 05 - May 05							
Number days	104	104	104	104	102	104	104
Percent of sample day	100.0%	100.0%	100.0%	100.0%	98.1%	100.0%	100.0%
Panel E: Ask Jan. 06 - May 06							
Number days	105	105	105	105	105	105	105
Percent of sample day	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Panel F: Bid Jan. 06 - May 06							
Number days	105	105	105	105	105	105	105
Percent of sample day	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 3.5: Comparison of Daily Mean Trading Volume with Daily Mean Best 1 Limit Order.
Notes: Comparisons of daily mean trading volume per transaction with daily mean of the Best 1 limit order per record on both Bid and Ask side are shown. The Best 1 limit order combines the Best 1 Bid and Best Ask 1 variables. The best bid price is defined as the highest price a prospective buyer is prepared to pay at a particular time for trading the futures contract. In the analyses, the variable Best 1 Bid is defined as the best bid depth, which corresponds to the sum of all bid sizes (number of contracts) that are submitted as limit orders for trading at the best bid price for market participant bid quotations that are equal to the best bid price. The best ask (or offer) price is the lowest price at which someone who owns the contract offers to sell it. Best 1 Ask is the best ask depth, which is the sum of all ask sizes (number of contracts) that are submitted as limit orders to trade at the best ask price for market participant ask quotations that are equal to the best ask price. Number days are the number of days that mean trading volume is less than or equal to the mean quote of the limit order. Percent of sample day is based on actual trading days.

To recap, it is quite evident that the best 1 limit order provides is a central determinant of the liquidity of the market. As shown above, most transactions have the order size that is much smaller that the sizes of the Best 1 limit order. To further highlight this issue, in Table 3.6, we show that there is a significantly positive correlation between daily mean trading volume per transaction (Mean Trade Volume) and mean Best 1 limit order on either bid side (Mean BIDQ) or ask side (Mean ASKQ).

Ahn et al. (2001) show that transitory volatility arises mainly from the paucity of limit orders at the best queue. Our finding in Table 3.6 of a significantly negative correlation between best 1 quotes (Mean *BIDQ* and Mean *ASKQ*) and the volatility of transaction prices (Std Price) consistent with Ahn et al. (2001)[3].

[3] This result is also in line with Biais et al. (1995) who find more trades occurred when the order book is thick, and more limit orders submitted when the book is thin. Hedvall and Niemeyer (1997) also report the presence of traders watching the limit order book and provide liquidity when spreads are large. Chung et al. (1999) find that, in the NYSE, more investors enter limit orders when the spread is wide, and more investors hit the quotes when the spread is tight. Gomber et al. (2004) find that large transactions are timed when liquidity is unusually high. In addition, Gilbert and Rijken (2006) state that firms need to trade more actively under the screen system if they are to transact comparable volumes to those undertaken in the open outcry regime.

	Mean *BIDQ*	Mean *ASKQ*	Mean Trade Volume	Max *BIDQ*	Max *ASKQ*	Max Trade Volume	Std *BIDQ*	Std *ASKQ*	Std Trade Volume	Std Price
Mean *BIDQ*	1									
Mean *ASKQ*	0.864	1								
Mean Trade Volume	0.487	0.397	1							
Max *BIDQ*	0.513	0.519	0.166	1						
Max *ASKQ*	0.513	0.576	0.186	0.522	1					
Max Trade Volume	0.022	-0.023	0.591	-0.027	-0.037	1				
Std *BIDQ*	0.836	0.866	0.299	0.725	0.654	-0.010	1			
Std *ASKQ*	0.791	0.863	0.276	0.624	0.819	-0.019	0.941	1		
Std Trade Volume	0.082	0.017	0.739	-0.021	-0.018	0.948	0.017	0.007	1	
Std Price	-0.192	-0.160	-0.184	0.070	0.062	-0.033	-0.020	-0.028	-0.100	1

Table 3.6 Correlation Matrix.

Notes: Correlation between trading activity and the Best 1 limit order is present. The sample has a total of 356 days from January 04, 2005 to May 30, 2006. Mean *BidQ* and Mean *AskQ* are the daily mean quantity of the Best 1 Bid or the Best 1 Ask per record in the data file; Std *BidQ* and Std *AskQ* are the daily standard deviation of the quantities of the Best 1 Bid or the Best 1 Ask per record in the data file; In the analyses, the variable Best 1 Bid is defined as the best bid depth, which corresponds to the sum of all bid sizes (number of contracts) that are submitted as limit orders for trading at the best bid price for market participant bid quotations that are equal to the best bid price. The best ask (or offer) price is the lowest price at which someone who owns the contract offers to sell it. Best 1 Ask is the best ask depth, which is the sum of all ask sizes (number of contracts) that are submitted as limit orders to trade at the best ask price for market participant ask quotations that are equal to the best ask price. Std Price is the daily standard deviation of transaction prices; Std Trade Volume is the standard deviation of the number of the SXF contract traded per transaction on each day. 356 daily data are used in the test. Absolute Pearson correlations are significant for critical values in excess of .1046 (.1368) at the 5% (1%) level of significance.

Foucault et al. (2005) argue that, in equilibrium, patient traders tend to submit limit orders, whereas impatient traders submit market orders. Markets with a high proportion of patient traders (as is the case here) or a small order arrival rate are more resilient.

Table 3.6 also shows that the pair-wise correlations among Std *BIDQ*, Std *ASKQ*, Std Trade Volume and Std Price are close to zero. These results are consistent with our conclusion that the best 1 limit orders are the central drivers of the SXF market. The majority of participants in the SXF market either make their trading decisions with respect to the best 1 limit order quote on the screen or adjust their trading behaviour in accordance with this quote. This is also consistent with Locke and Sarkar (2001) and Bortoli et al. (2006)[4].

In sum, **our inability to find any significant relationship between (carefully measured), transaction costs with measures of trading activities** is consistent with the market operating during a period of normal volatility, with the **limit order book (Best 1 quotes) supplying adequate liquidity, where buy and sell orders are consummated at the Best 1 quotes**.

In Table 3.7, we test the different measures of the best 1 order and trading of the SXF market for unit roots market by using the Augmented Dickey-Fuller (ADF) test with four lags for the 356 daily data.

As shown in the table, all the measures show mean reversion in our sample period when an intercept is included in the test. Moreover, we find significant *p* value of less than 0.01 for all

[4] Locke and Sarkar (2001) examine the provision of liquidity in futures markets as price volatility changes and find that customer trading costs do not increase with volatility. They conclude that there is adequate liquidity during volatile periods in electronic systems

measures when an intercept and trend model is used to the tests[5]. The unit root test results are consistent with a dynamic competitive equilibrium process for the SXF market, where shocks to the variables do not have persistent effects.

	Augmented Dickey-Fuller		Augmented Dickey-Fuller		Augmented Dickey-Fuller		Augmented Dickey-Fuller		Augmented Dickey-Fuller	
	Intercept	None	Intercept	None	Intercept	None	Intercept	None	Intercept	None
Panel A: Market										
	Mean *BidQ*		Mean *AskQ*		Std *BidQ*		Std *AskQ*		Std Price	
SXF	0.000	0.086	0.000	0.097	0.000	0.007	0.000	0.007	0.000	0.187
Panel B: Account Type										
Variable	All		Client		Firm		Pro			
Number Trade	0.001	0.344	0.001	0.293	0.001	0.340	0.000	0.314		
Mean Trade Volume	0.000	0.263	0.000	0.182	0.000	0.278	0.003	0.458		
Std Trade Volume	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.078		
Variable	Hedger		Speculator		Market Maker					
Number Trade	0.002	0.238	0.005	0.397	0.000	0.275				
Mean Trade Volume	0.000	0.175	0.000	0.318	0.005	0.398				
Std Trade Volume	0.000	0.000	0.000	0.000	0.000	0.006				

Table 3.7 Unit Root Tests on the Daily Measures of the SXF Market Activity.
Notes: MacKinnon (1996) one-sided *p*-values of Augmented Dickey-Fuller tests with four lags on daily measures of the SXF market activity are presented. Column Intercept and None are the results of Augmented Dickey-Fuller model with or without intercept respectively. In Panel A, Mean *BidQ* and Mean *AskQ* are the daily mean quantity of the best1 Bid or the best1 Ask per record in the data file; Std *BidQ* and Std *AskQ* are the daily standard deviation of the quantities of the best1 Bid or the best1 Ask per record in the data file; Std Price is the daily standard deviation of transaction prices. In Panel B, Column All is the transaction by all participants in the SXF market; Client is the results from buy or sale by the aggregated Client; Firm is the results from buy or sale by the aggregated Firm; Pro is the results from buy or sale by the aggregated Pro; Hedger is the results from transaction by Hedgers, Speculator is the results from transaction by Speculator and Market Maker is the results from transaction by Market Maker. In the column Variable, Number Trade is the number of trading on each day; Mean Trade Volume is the daily mean of the number of the SXF contract traded per transaction; and Std Trade Volume is the standard deviation of the number of the SXF contract traded per transaction on each day. Data over 356 trading days are used in the test.

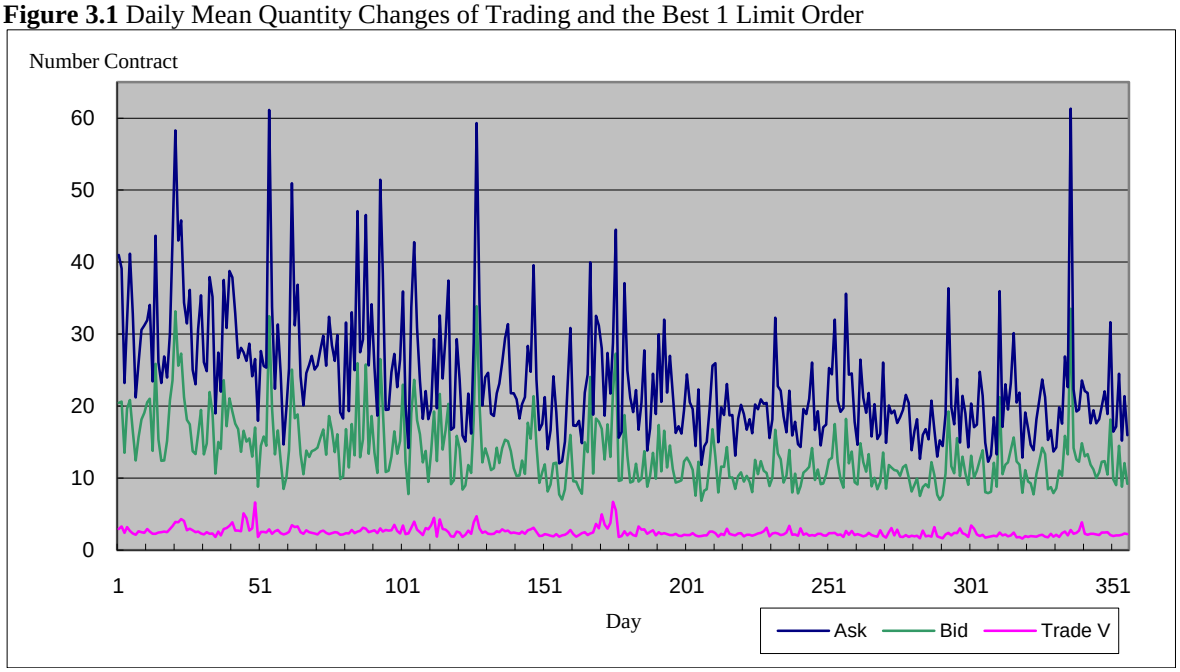
Figure 3.1 and Figure 3.2 illustrate the mean reverting behaviour of the measures of market activities in our sample period; in addition, Figure 3.1 also demonstrates that the size of trading per transaction is much less than the sizes of the Best 1 limit orders.

3.3. Cost, Spreads, and Minimum Tick Sizes

To provide further evidence that SXF market is in equilibrium and the inappropriateness of spreads in an equilibrium limit order market, we also calculate the spreads.

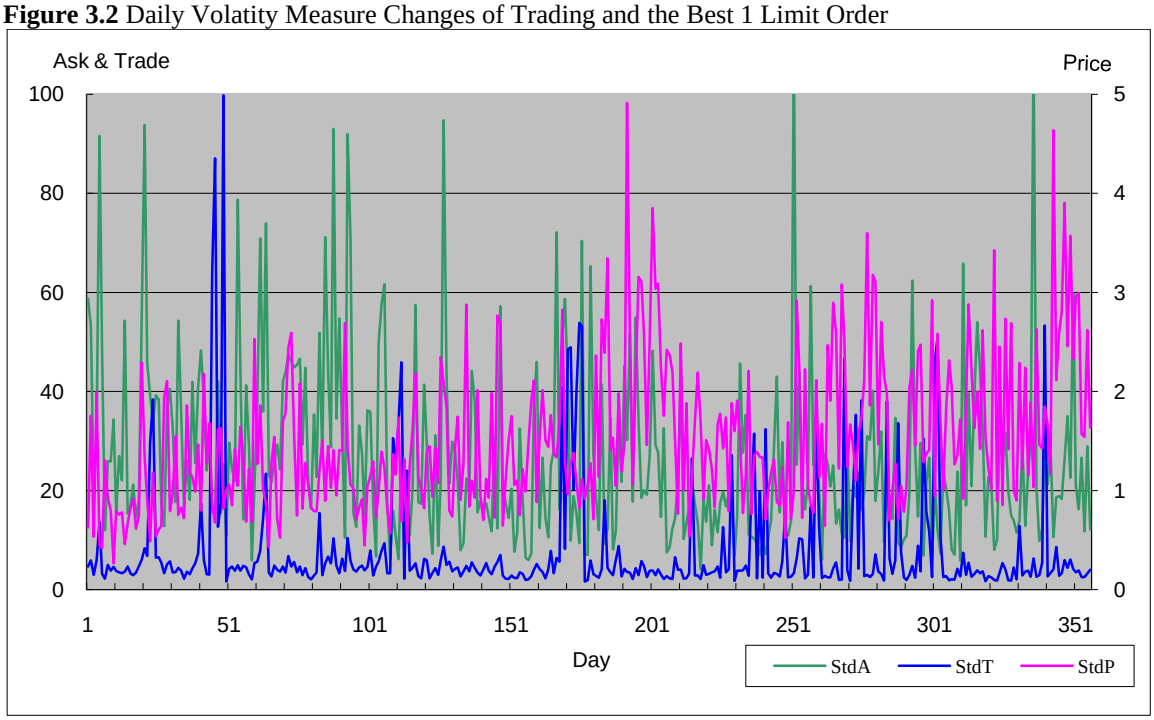
[5] The results for trend and intercept model are not reported in the table to save space.

Figure 3.1 Daily Mean Quantity Changes of Trading and the Best 1 Limit Order



Notes: Figure 3.1 shows the daily mean trading volume (Trade V) per transaction, the daily mean quantity of the Best 1 Bid (Bid) and the daily mean quantity of the Best 1 Ask (Ask) per record in the data file over the sample period (356 trading days).

Figure 3.2 Daily Volatity Measure Changes of Trading and the Best 1 Limit Order



Notes: Figure 3.2 shows, the daily standard deviation of trading volume per transaction (StdT), the daily standard deviation of the Best 1 Ask quantity per record (StdA) and the daily standard deviation of transaction price (StdP) are present. The axis of Ask& Trade is for StdT and StdA; the axis of Price is for StdP. The sample has 356 trading days.

The best bid price is defined as the highest price a prospective buyer is prepared to pay at a particular time for trading the futures contract. In the analyses, the variable Best 1 Bid is defined as the best bid depth, which corresponds to the sum of all bid sizes (number of contracts) that are submitted as limit orders for trading at the best bid price for market participant bid quotations that are equal to the best bid price. The best ask (or offer) price is the lowest price at which someone who owns the contract offers to sell it. Best1 Ask is the best ask depth, which is the sum of all ask sizes (number of contracts) that are submitted as limit orders to trade at the best ask price for market participant ask quotations that are equal to the best ask price.

Quote Type	Sample Period	mean Spread1	mean Spread2	Std Spread1	Std Spread2
Best1	Jan. 05 – May 06	0.2503	0.0467	1.1336	0.3226
	Jan.05 - May 05	0.1912	0.0365	0.1079	0.0206
	Jan.06 - May 06	0.3411	0.0674	3.1670	0.9225
Best2	Jan. 05 – May 06	0.4877	0.0820	0.3513	0.0585
	Jan.05 - May 05	0.4380	0.0836	0.2420	0.0461
	Jan.06 - May 06	0.5182	0.0771	0.3947	0.0589

Table 3.8 Statistics of the SXF Spreads.
Notes: Average daily mean and standard deviation of the SXF spreads is present in the table. The best bid price is defined as the highest price a prospective buyer is prepared to pay at a particular time for trading the futures contract. In the analyses, the variable Best 1 Bid is defined as the best bid depth, which corresponds to the sum of all bid sizes (number of contracts) that are submitted as limit orders for trading at the best bid price for market participant bid quotations that are equal to the best bid price. Best 2 Bid is the second best bid depth, and so forth. The best ask (or offer) price is the lowest price at which someone who owns the contract offers to sell it. The SXF minimum tick is 0.05; Spread1 =Ask Price – Bid Price; Spread2= (Ask Price-Bid Price)*2/ (Ask Price + Bid Price)*100. The sample period covers 356 records from Jan.2005 to May2006.

	Profit Trade	Profit Settled Client	Average Profit	Profit Trade	Profit Settled Firm	Average Profit	Profit Trade	Profit Settled Pro	Average Profit
Jan-May 2005	-35.43	-23.13	-42.76	22.63	43.43	45.69	21.26	8.81	21.33
Jan-May 2006	-36.72	-0.29	-22.85	43.01	-16.98	6.96	7.61	15.30	7.11
All	-34.03	-0.05	-31.69	29.43	-0.14	25.59	13.68	13.28	13.81
		Hedger			Speculator			Market Maker	
Jan-May 2005	10.10	15.19	13.41	-19.91	-6.03	-17.15	-0.09	1.92	-1.32
Jan-May 2006	9.85	-2.51	-5.69	-20.83	-1.46	-12.10	-12.28	7.67	-6.26
All	1.46	-20.32	-5.99	-18.58	13.51	-6.07	-2.99	6.03	-2.22

Table 3.9 Daily Mean Transaction Cost of SXF (C$).
Notes: Sample periods are 356 days from January 04, 2005 to May 31, 2006. Profit trade is calculated by the FIFO rule for each account type. Profit Settled is the assumed profits by settling the closing position (at the end of a trading day) at the closing average of bid and ask price of contracts. Average Profit is a weighted average of Profit trade and Profit Settled with the weights in accordance with the number of contracts. Costs of the most nearby standard SXF contract are present in the table. Minimum Tick of SXF is C$10.00. Two sub-periods of the sample from January 2005 to May 2005, from January 2006 to May2006 and for the whole sample period (All) are presented.

Table 3.8 shows that the average of daily mean spreads and daily standards deviation of spreads for SXF in our sample period. In the table, the Best 1 limit order combines the Best 1 Bid and Best Ask 1 variables. The best bid price is defined as the highest price a prospective buyer is prepared to pay at a particular time for trading the futures contract. In the analyses, the variable Best 1 Bid is defined as the best bid depth, which corresponds to the sum of all bid sizes (number of contracts) that are submitted as limit orders for trading at the best bid price for market participant bid quotations that are equal to the best bid price. The best ask (or offer) price is the lowest price at which someone who owns the contract offers to sell it. Best 1 Ask is the best ask depth, which is the sum of all ask sizes (number of contracts) that are submitted as limit orders to trade at the best ask price for market participant ask quotations that are equal to the best ask price. We calculate two measures for bid-ask spreads.

$$\text{Spread1} = \text{Ask Price} - \text{Bid Price} \tag{3.2}$$

$$\text{Spread2} = (\text{Ask Price} - \text{Bid Price}) * 2 / (\text{Ask Price} + \text{Bid Price}) * 100 \tag{3.3}$$

Table 3.9 shows the mean daily FIFO cost results on the front SXF contract.

From Table 3.8, we note that the averages of daily mean spread (Spread 1) are much higher than the SXF minimum tick of 0.05. Table 3.9 shows that the costs are much higher than the value of the SXF minimum tick (C$ 10).

Several empirical papers have examined the impact of tick size changes on market quality. For example, Bacidore (1997), Ahn et al. (1998) and Griffiths et al. (1998) study reduction of tick size on the TSE in 1996. Goldstein and Kavajecz (2000) and Chordia et al. (2001) show that the inside spread significantly decreased, but depth at the best bid and ask also decreased after the reduction in tick size of the NYSE. Kurov and Zabotina (2005) find that the minimum tick sizes of the E-mini S&P 500 and E-mini Nasdaq-100 futures contracts preventing the spreads from decreasing to the levels implied by a competitive market. In addition, Bortoli et al. (2006) report that trading at the minimum tick in the Sydney Futures Exchange embraces 87.8% of observations for the SPI, 95.2% for bank-accepted bills, 97.8% for three-year bonds, and 94.4% for ten-year bonds in the periods before or after the Sydney Futures Exchange changed the limit order disclosure rule.

In the SXF market, however, the spread and costs are much higher than the minimum tick size. Hence, it is clear the established spread/ minimum tick size may not be reflective of the market at any particular point in time[6].

In addition, from Table 3.8 we note that the average mean daily spreads and the average daily standard deviation of the spreads are higher in the first five months of 2006 than those of the first five months of 2005. However, the corresponding FIFO costs for all six aggregated account types are lower in the first five months of 2006 (Table 3.9). Since more transactions could reduce transaction costs, and the trading volume is much higher in the first five months of 2006 than those of the first five months of 2005 (Panel B and Panel C of Table 3.3), it is evident that trading costs are not well captured by spreads for the SXF market.

In the work, we also perform regression analysis on the costs and spreads with the model of Equation 1, substituting the quantity of limit orders (Q) in the model with Spreads. These results are shown in Table 3.10. The lack of significance of the explanatory variables holds whether Spread1 or Spread2 is used in the regression; consistent with Locke and Venkatesh (1997), daily mean spreads (*BA*) and standard deviation of daily spreads (*std BA*) show no relationship with transaction costs.

Overall, the results show that traditional spreads have no relationship with the trading costs in the SXF market and that the minimum tick size do not act as binding constraints on the bid-ask spreads and costs.

In fact, spreads as the measures of transaction costs need very strong assumption that all transactions are go through market makers. Since Client in our sample has much more transactions than Pro/Market maker, such an assumption clear does not held in SXF market. However, our FIFO cost is extensively used in accounting book keeping and is direct measure costs. The finding that no relationship between FIFO costs and spreads further supports that traditional spreads are inappropriate as the measure of trading costs, especially in a full electronic market.

[6] Indeed, shortly after the endpoint of our data, **the Exchange raised the minimum tick - the minimum tick size was raised to C$20 per tick (minimum tick fluctuation has been increased from 0.05 index points to 0.10 index points)!**

Account	Dependent		Independent Variable									
			C	*BA*	*TV*	*std BA*	*std TV*	*std P*	*D*	*PF*	*DW*	*RSQ*
Client	Average profit	Coef.	-92.02	-0.82	20.74	0.03	-0.99	29.55	36.77			
		Prob.	0.04	**0.04**	0.20	0.16	0.45	**0.01**	0.44	0.04	2.00	0.04
	Profit trade	Coef.	-152.4	-0.75	43.10	0.02	-1.70	34.36	-7.30			
		Prob.	0.00	**0.05**	**0.01**	0.33	0.18	**0.00**	0.87	0.00	2.05	0.06
Firm	Average profit	Coef.	89.97	1.45	-24.39	-0.05	5.81	-54.65	-143.2			
		Prob.	0.27	**0.05**	0.33	0.22	0.28	**0.01**	0.58	0.05	1.94	0.04
	Profit trade	Coef.	221.2	1.27	-63.01	-0.03	8.14	-63.59	-102.4			
		Prob.	0.00	0.06	**0.01**	0.35	0.10	**0.00**	0.67	0.00	1.97	0.06
Pro	Average profit	Coef.	-12.63	0.12	11.93	-0.01	1.23	-0.36				
		Prob.	0.70	0.39	0.60	0.40	0.91	0.92		0.87	1.93	0.01
	Profit trade	Coef.	27.94	0.09	-14.38	-0.01	6.78	-0.78				
		Prob.	0.38	0.52	0.53	0.42	0.52	0.84		0.95	2.02	0.00
Hedger	Average profit	Coef.	-3.66	1.34	-3.25	-0.07	0.36	-30.11	-22.20			
		Prob.	0.94	**0.00**	0.83	**0.00**	0.80	**0.02**	0.68	0.01	1.86	0.04
	Profit trade	Coef.	43.08	0.70	-7.86	-0.02	0.47	-33.54	-16.97			
		Prob.	0.28	0.06	0.54	0.23	0.71	**0.00**	0.72	0.04	2.04	0.04
Spec	Average profit	Coef.	56.62	-1.53	-6.06	0.09	-2.01	9.83	117.1			
		Prob.	0.34	**0.00**	0.80	**0.00**	0.37	0.42	0.30	0.01	1.59	0.05
	Profit trade	Coef.	-15.79	-0.61	-0.68	0.03	-1.20	18.02	65.84			
		Prob.	0.72	0.06	0.97	0.10	0.47	**0.05**	0.43	0.21	2.03	0.02
Market Maker	Average profit	Coef.	16.93	-0.10	-10.34	0.00	1.21	1.99	-164.6			
		Prob.	0.51	0.47	0.52	0.49	0.81	0.61	**0.01**	0.00	1.91	0.06
	Profit trade	Coef.	57.53	-0.27	-23.82	0.00	-5.36	-0.50	-72.25			
		Prob.	0.05	0.07	0.19	0.76	0.36	0.91	0.33	0.00	1.92	0.07

Table 3.10 OLS Estimates of the Regression of SXF Transaction Costs with Measures of Trading Activity and Spreads

Notes: OLS estimates of the regression of SXF daily transaction profit/Cost in C$ per contract on measures of trading activity and spreads are shown. *BA* is the daily mean Spread1 of Best 1 for Panel A and is the daily mean Spread2 for Panel B. The best bid price is defined as the highest price a prospective buyer is prepared to pay at a particular time for trading the futures contract. In the analyses, the variable Best 1 Bid is defined as the best bid depth, which corresponds to the sum of all bid sizes (number of contracts) that are submitted as limit orders for trading at the best bid price for market participant bid quotations that are equal to the best bid price. Best 2 Bid is the second best bid depth, and so forth. The best ask (or offer) price is the lowest price at which someone who owns the contract offers to sell it. Best 1 Ask is the best ask depth, which is the sum of all ask sizes (number of contracts) that are submitted as limit orders to trade at the best ask price for market participant ask quotations that are equal to the best ask price. Best 2 Ask is the second best ask depth; Spread1 =Ask Price – Bid Price; and Spread2= (Ask Price-Bid Price)*2/ (Ask Price + Bid Price)*100. *TV* is Mean Trade Volume. *D* is a dummy variable, which equals 1 when *TV* +3 * *Std TV*> *Q* + 3 **Std Q*; and *Q* is the daily mean quantity of Best 1 Ask for Panel A and Best 1 Bid for Panel B; Std stands for standard deviation. P is transaction price. *DW* is Durbin-Watson stat. PF is the p value of the regression; RSQ is R square of the regression, Profit trade is daily FIFO profit for each account type of Firm, Client, Pro, Hedger, Speculator (Spec) and Market Maker. Average profit is the weighted average profits of the FIFO profit and the profits of daily inventory imbalance settled at the closing price. The number of contracts traded or settled is used as the weighting variable. *C* is constant term in the OLS model. 356 daily data from January 04, 2005 to May 31, 2006.are used in the regression. Value in Bold indicates significant at 5 percent level.

3.4. Analyses of Transactions by Order Type

In the work, we also differentiate SXF transaction across order types with another trade data file that recodes each trade with Limit, Market or Market on Opening in the Order Type identifier from March 01 2005 to April 28 2006. Table 3.11 summarizes the SXF transactions by order type.

Account	Dependent		Independent Variable									
Panel B: Spread2			*C*	*BA*	*TV*	*std BA*	*std TV*	*std P*	*D*	*PF*	*DW*	*RSQ*
	Average profit	Coef.	-109.0	-639.04	23.72	23.53	-1.12	28.23	35.84			
		Prob.	0.01	**0.02**	0.14	0.10	0.39	**0.01**	0.45	0.03	2.00	0.04
	Profit	Coef.	-167.5	-607.83	45.98	18.01	-1.83	33.14	-8.27			
Client	trade	Prob.	0.00	**0.02**	**0.00**	0.20	0.15	**0.00**	0.86	0.00	2.05	0.06
	Average profit	Coef.	118.6	1118.6	-29.10	-38.06	6.63	-52.19	-184.9			
		Prob.	0.13	**0.03**	0.25	0.15	0.29	**0.01**	0.57	0.03	1.94	0.04
	Profit	Coef.	246.4	986.14	-66.94	-28.21	8.64	-61.51	-125.3			
Firm	trade	Prob.	0.00	**0.03**	**0.00**	0.25	0.13	**0.00**	0.68	0.00	1.97	0.07
	Average profit	Coef.	-8.83	84.19	10.72	-4.22	1.20	-0.25				
		Prob.	0.78	0.36	0.64	0.38	0.91	0.95		0.86	1.93	0.01
	Profit	Coef.	30.42	84.66	-15.50	-5.01	6.81	-0.68				
Pro	trade	Prob.	0.33	0.36	0.49	0.29	0.52	0.86		0.91	2.02	0.00
	Average profit	Coef.	23.26	1022.8	-7.24	-53.63	0.55	-27.80	-15.31			
		Prob.	0.60	**0.00**	0.63	**0.00**	0.71	**0.03**	0.77	0.01	1.86	0.05
	Profit	Coef.	60.91	494.64	-10.90	-17.29	0.74	-32.70	-23.08			
Hedger	trade	Prob.	0.12	0.06	0.40	0.20	0.56	**0.00**	0.61	0.04	2.04	0.04
	Average profit	Coef.	18.47	-1074.4	1.05	63.23	-2.18	7.24	115.3			
		Prob.	0.75	**0.00**	0.96	**0.00**	0.33	0.55	0.31	0.00	1.59	0.05
	Profit	Coef.	-31.59	-404.13	1.96	18.55	-1.26	17.03	64.83			
Spec	trade	Prob.	0.46	0.07	0.91	0.11	0.45	0.06	0.44	0.23	2.03	0.02
	Average profit	Coef.	13.46	-79.19	-8.86	-2.62	1.02	1.89	-164.6			
		Prob.	0.59	0.39	0.58	0.58	0.84	0.62	**0.01**	0.00	1.91	0.06
Market	Profit	Coef.	47.16	-120.65	-21.24	-1.38	-5.76	-0.71	-73.07			
Maker	trade	Prob.	0.10	0.25	0.24	0.80	0.33	0.87	0.33	0.00	1.92	0.07

Table 3.10 (Cont.) OLS Estimates of the Regression of SXF Transaction Costs with Measures of Trading Activity and Spreads

Notes: OLS estimates of the regression of SXF daily transaction profit/Cost in C$ per contract on measures of trading activity and Spreads are presented. In the table, *BA* is the daily mean Spread1 of Best 1 for Panel A and is the daily mean Spread2 for Panel B. The best bid price is defined as the highest price a prospective buyer is prepared to pay at a particular time for trading the futures contract. In the analyses, the variable Best 1 Bid is defined as the best bid depth, which corresponds to the sum of all bid sizes (number of contracts) that are submitted as limit orders for trading at the best bid price for market participant bid quotations that are equal to the best bid price. Best 2 Bid is the second best bid depth, and so forth. The best ask (or offer) price is the lowest price at which someone who owns the contract offers to sell it. We define Best1 Ask as the best ask depth, which is the sum of all ask sizes (number of contracts) that are submitted as limit orders to trade at the best ask price for market participant ask quotations that are equal to the best ask price. Best 2 Ask is the second best ask depth.
Spread1 =Ask Price – Bid Price; and Spread2= (Ask Price-Bid Price)*2/ (Ask Price + Bid Price)*100.
TV is Mean Trade Volume. *D* is a dummy variable, which equals 1 when *TV* +3 * *Std TV*> *Q* + 3 **Std Q*; and *Q* is the daily mean quantity of Best 1 Ask for Panel A and Best 1 Bid for Panel B. Std stands for standard deviation. P is transaction price. *DW* is Durbin-Watson stat. PF is the p value of the regression. RSQ is R square of the regression, Profit trade is daily FIFO profit for each account type of Firm, Client, Pro, Hedger, Speculator (Spec) and Market Maker. Average profit is the weight average profits of the FIFO profit and the profits of daily inventory imbalance settled at the closing price. The number of contracts traded or settled is used as the weight. *C* is constant term in the OLS model. 356 daily data from January 04, 2005 to May 31, 2006.are used in the regression. Value in Bold indicates significant at 5 percent level.

Harris and Hasbrouck (1996) document that 54 percent of SuperDot orders are limit orders. Ross et al. (1996) report that limit orders account for 65 percent (75 percent) of all executed orders (executed shares) in SuperDot. Compared with these results, limit orders are used much more extensively in SXF trades. As shown in the table, Limit order accounts for 97.70 percent of all trades on the nearby SXF contract (Limit to All) when measured by the number of trades; the account for 94.11 percent of all trades on the nearby SXF contract when

measured by the number of contracts traded. Only very small proportion of the SXF trades were conducted through Market on Opening (Mo) or Market order (Mkt).

	By Number of Trade			By Trade Volume		
	Limit To All	Mkt To All	Mo To All	Limit To All	Mkt To All	Mo To All
Average Daily	97.70%	1.67%	0.63%	94.11%	1.19%	4.08%
Whole Sample	97.45%	1.96%	0.58%	92.97%	1.13%	4.91%

Table 3.11 Summary of the SXF Transaction by Order Type

Notes: The summary of the SXF transaction by order types is presented. Average Daily is the results by calculating the percentages on each day and then calculating the average for the sample period; Whole Sample is the results by calculating the sum of the number of trade/the trade volume on the sample period and then calculating the percentage for the sample period. All is all records without classifying a trade by order types. Limit, Mkt and Mo are Limit, Market and Market on Opening in a trade data file that recodes each trade with Limit, Market or Market on Opening in the Order Type from March 01 2005 to April 28 2006.

In such a market where limit orders are used by most transactions, the role of limit order book must be more important. When the best 1 quote book in the market provides enough liquidity/buffer to absorb potential trading orders, transaction costs should not be expected to be related to with measures of trading activities. On the other hand, to ameliorate price impact and informational leakage effects, investors looking to open or close large positions may need to structure their orders according to the depth of the best 1 limit order, to ameliorate price impact and information leakage effects.

4. CONCLUSION

Using a unique database that includes the quotes and trade characteristics of the SXF market from January 2005 to May 2006 on the index futures of the SXF with aggregated trader types identified and time stamped in millisecond from the Montreal Exchange, We find that transactions costs, as correctly measured are not related to measures of trading activity, in both pair-wise correlation analyses as well as in a regression framework when limit orders provide enough liquidity for markets, especially for electronic systems.

The limit order book conveys information about the market. Statistics of transaction by order type show that almost all trades are executed by limit orders for SXF market.

We find a significant role for limit orders, especially that of depth 1 in determining participants' trading behaviour, and in providing liquidity to the market. In addition, the results highlight the inability of traditional spreads to measure trading costs.

All our level or volatility measures of quotes and trades by every aggregated account show evidence of mean reversion. This is consistent with a dynamic equilibrium process for the SXF market, wherein shocks to the variables do not have permanent dislocating effects. Moreover, the fact that the costs or spreads are much higher than the minimum tick size also implies participants in the SXF market respect the limit order to make their investment decision.

Although participants in a limit order market can employ different order placement strategies, the aggregated actions of the participants still can leads the market to dynamic equilibrium when a majority of the participants have, on aggregated basis, established trading proclivities. In such an equilibrium system, the aggregated trading costs will not follow the fluctuations of various traditional market activity measures. Studying the overall equilibrium of electronic

systems for other derivative markets and the role of limit order book in determining the participants' trading behaviour remains a topic for future work.

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